Announcements

- Homework for tomorrow…

  (Ch. 25, CQ 12, Probs. 22, 60, & 66)

  CQ3: q_A = -, q_C = +, q_B = q_D = 0

  CQ4: a) yes, q_{obj} = $q_{plastic}$ = - b) no, q_{obj} = + or q_{obj} = 0

  25.2: a) e's were removed b) 5 x 10^{10}

  25.10: 1) with neutral metal spheres touching, touch one with charged rod, 2) remove charged rod from vicinity, 3) separate spheres

  25.11: 1) with neutral metal spheres touching, bring charged rod near one, 2) separate spheres, 3) remove charged rod from vicinity

- Office hours…

  MW 10-11 am

  TR 9-10 am

  F 12-1 pm

- Tutorial Learning Center (TLC) hours:

  MTWR 8-6 pm

  F 8-11 am, 2-5 pm

  Su 1-5 pm

Chapter 25

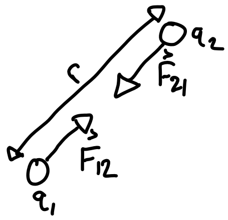
Electric Forces & Charges

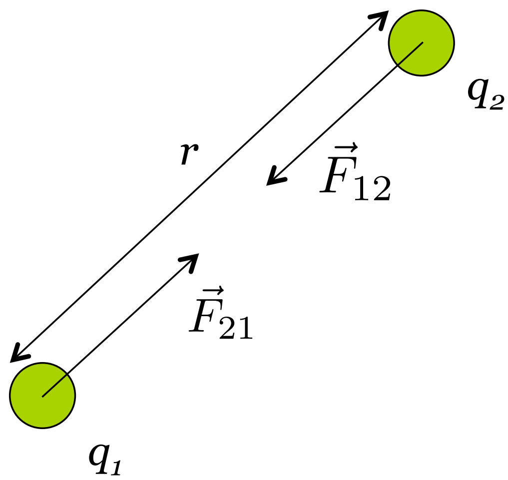
(*The Electric Field*)

Last time…

- Coulomb's Law

$$F_{12} = F_{21} = \frac{K|q_1||q_2|}{r^2}$$





- So, how does q_1 know that q_2 is there?

The Electric Field…

Postulate a *field model* that describes how q's interact:

1. *Source charges* alter the space around them by creating an *electric field* $\vec{E}$.

2. A *separate charge in* the electric field experiences a force $\vec{F}$ exerted *by the field*.

Electric Field..

$$\vec{E} \equiv \frac{\vec{F}_{on\ q}}{q}$$

Electric Field

$\vec{E} = \frac{\vec{F}_{on\ q}}{q}$

$\vec{F} = q\vec{E}$

SI Units:

$$[\vec{E}] = \frac{[\vec{F}]}{[q]} = \frac{N}{C}$$

Notice:

- The *magnitude* of E is the *electric field strength*.

The Electric Field model…

The *field* is the agent that exerts an electric force on a charged particle.

$$\vec{E} \equiv \frac{\vec{F}_{on\ q}}{q}$$

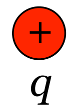
Notice:

1. Our equation for ***E*** assigns a *vector* to *every point* in space.
2. The electric field vector points in the *same direction* as the force on a *positive charge*.
3. Electric field depends *only* on the *source charge* (it's *independent* of the *test charge*).

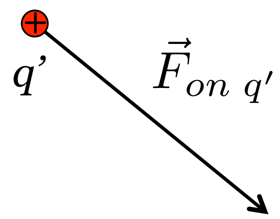
The Electric Field of a Point Charge

Consider a *source charge q* and a *test charge q’*...

The *FORCE* on *q’* due to *q* is...

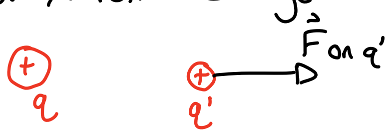


$$\boxed{\vec{F}_{on\ q'} = \frac{Kqq'}{r^2},\ \text{away from } q}$$



Electric Field of A Point Charge

$$\vec{F}_{on\ q'} = \frac{Kqq'}{r^2}$$



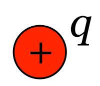
The Electric Field of a Point Charge

Consider a *source charge q* and a *test charge q'*...

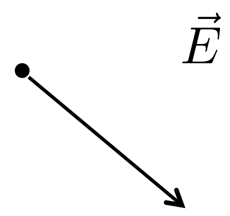
The *ELECTRIC FIELD* due to *q* is...

$\vec{E} = \frac{Kq}{r^2}$

+ q $\xrightarrow{\vec{E}}$



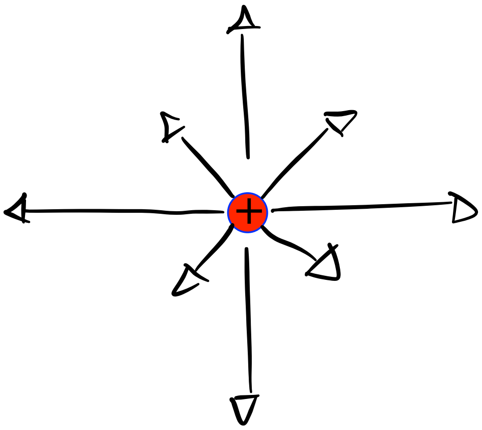
$$\boxed{\vec{E} = \frac{Kq}{r^2}, \text{ away from } q}$$



$$\vec{E} = \frac{\vec{F}\,Q'}{Q'} = \frac{Kqa'}{r^2} \cdot \frac{1}{q'} = \frac{Kq}{r^2}$$

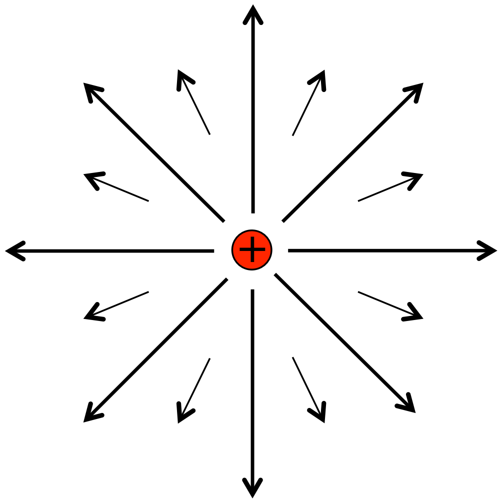
The Electric Field Diagram…

Q: So, what does the electric field diagram look like for a *positive charge*?



The Electric Field Diagram…

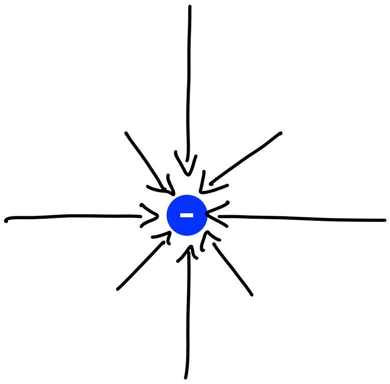
Rules for drawing an ***electric field diagram***..



1. Field exists at *all* points in space. Field diagram is a *representative sample*.
2. The arrow indicates the *direction* and *strength* of the electric field at the *point to which it is attached*.

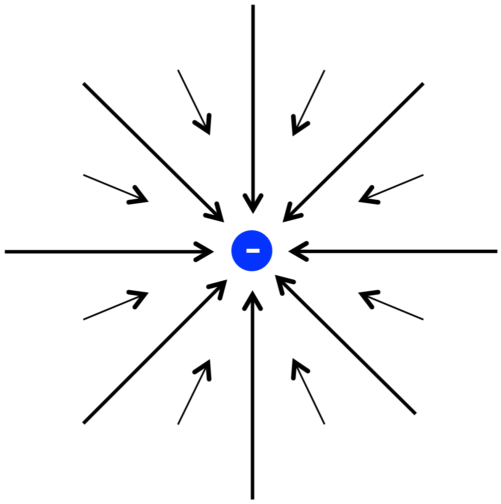
The Electric Field Diagram…

Q: What does the electric field diagram look like for a *negative charge*?



The Electric Field Diagram…

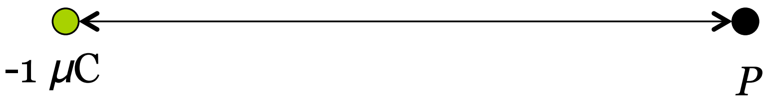
Q: What does the electric field diagram look like for a *negative charge*?



A: The electric field of a *negative charge*

Quiz Question 1

Point P is located at r = 1 m away from a -1 μC point charge. Which of the following statements is/are true:



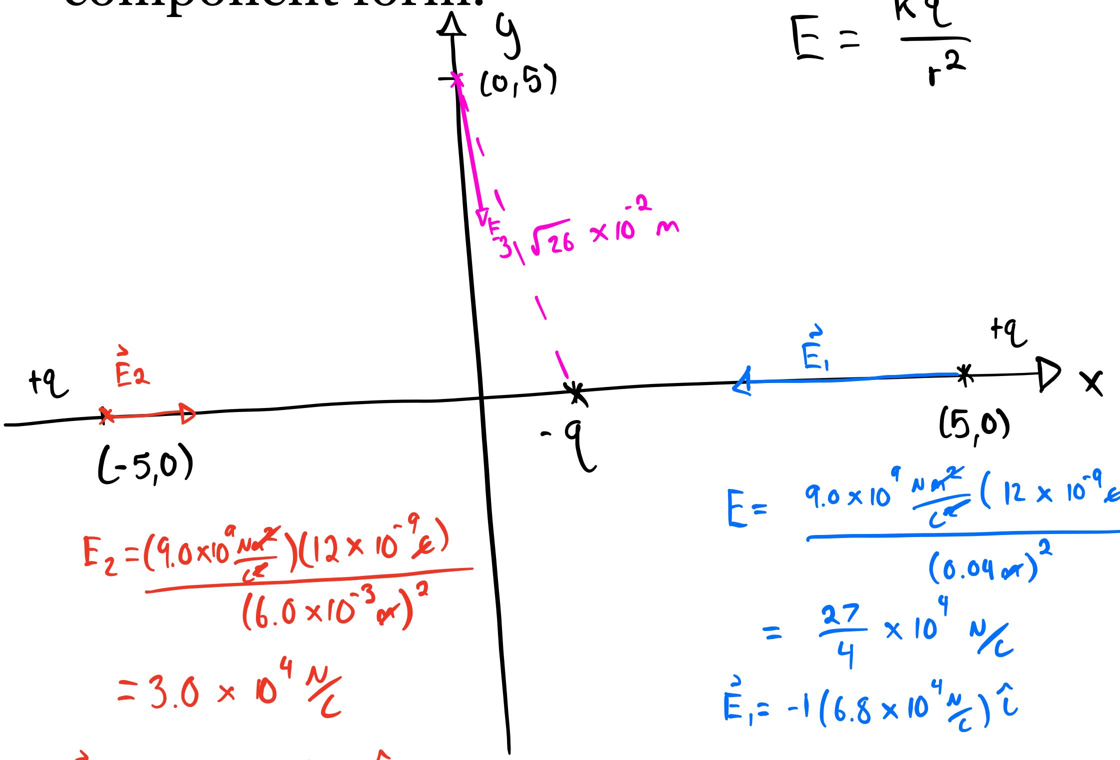
I. The electric field at P points to the right.
II. The electric field at P is *zero* since no charge is located there.
III. *Doubling* r will *halve* the electric field.

1. I only.
2. II only.
3. I and II.
4. II and III.
5. None of these.

Exercise 25.27

A -12 nC charge is located at (x, y) = (1.0 cm, 0 cm). What are the electric fields at the positions (x, y) = (5.0 cm, 0 cm), (-5.0 cm, 0 cm), and (0 cm, 5.0 cm)? Write the electric field vector in component form.

$$E = \frac{kq}{r^2}$$



$$E_2 = \frac{(9.0\times10^9 \frac{Nm^2}{C^2})(12\times10^{-9} C)}{(6.0\times10^{-3} m)^2}$$

$$= 3.0 \times 10^4 \, N/C$$

$$\vec{E}_2 = (3.0 \times 10^4 \, N/C)\hat{i}$$

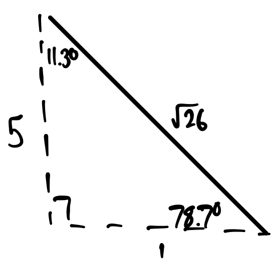
$$E = \frac{9.0\times10^9 \frac{Nm^2}{C^2}(12\times10^{-9} C)}{(0.04 \, m)^2}$$

$$= \frac{27}{4} \times 10^4 \, N/C$$

$$\vec{E}_1 = -1(6.8\times10^4 \, N/C)\hat{i}$$

$$\vec{E}_3 = \frac{(9.0\times10^9 \frac{Nm^2}{C^2})(12\times10^{-9} C)}{26\times10^{-4} m^2}$$

$$\vec{E}_3 = 4.2 \times 10^4 \, N/C$$



$\tan\theta = \frac{5}{1}$

$\theta = \tan^{-1}(5)$

$$E_{3x} = 4.2\times10^4 \, N/C \cos 78.7°$$
$$= (0.82\times10^4 \, N/C)\hat{i}$$
$$E_{3y} = -4.2\times10^4 \, N/C \sin 11.3°$$
$$= -(4.1\times10^4 \, N/C)\hat{j}$$

$$(0.82\times10^4 \, N/C)\hat{i} - (4.1\times10^4 \, N/C)\hat{j}$$

Problem 25.58

Two 5.0 g point charges on 1.0-m-long threads repel each other after being charged to +100 nC, as shown in the fig. below.

What is the angle θ? You can assume that θ is a small angle.

$$\Sigma \vec{F}_y = 0$$

$$T\cos\theta - mg = 0$$

$$T\cos\theta = mg$$

$$\Sigma \vec{F}_x = 0$$

$$F_e - T\sin\theta = 0$$

$$F_e = T\sin\theta$$

$$F_e = \frac{Kq^2}{2\ell\sin\theta}$$